Report of the Review Committee
on the

AGS Upgrade Proposal

Rare Symmetry Violating Processes (RSVP) Project

Brookhaven National Laboratory
November 4-5, 2004

Executive Summary

The Rare Symmetry Violating Process (RSVP) Project AGS Upgrade Review Committee was convened at the Brookhaven National Laboratory on November 4-5, 2004. The Committee was formed at the request of W. Willis, RSVP Project Director, and Jonathan Kotcher, Deputy Director, who report to an NSF-DOE Joint Oversight Group and oversee the AGS Upgrade as well as RSVP experiments. The Committee's charge was to assess the proposed technical scope, cost, schedule and management of the AGS Upgrade portion, with particular emphasis on the problem of budget estimate growth since the entire RSVP experimental and upgrade program was reviewed by a DOE Lehman Committee in January 2004. Unlike the Lehman review, this Committee was to examine the AGS Upgrade portion, in particular to understand the technical proposal and its attendant cost issues.

The Committee noted the results of the Lehman Committee, which was charged primarily with reviewing the technical and operational proposal to assure the RSVP upgrade and operations would not interfere in any significant manner with RHIC operations. Lehman concluded favorably, and recommended further rapid development. Although the Lehman report noted possible higher failure rates and longer repair times due to higher intensity beams that must be developed for both experiments that could affect RHIC operations, nonetheless it concluded "minimal impact" and "plausible solutions" for the potential problems.

Since that report was issued, the cost estimate for the AGS Upgrade has escalated approximately by a factor of two, and this Committee was asked to try to understand why, and what might be done to reduce or defer some portion of the proposed program costs.

The Committee heard a full day of presentations covering all the requested subject matter, and was impressed with the significant technical and planning progress made since the signing of a DOE-NSF Memorandum of Understanding in August 2004. The second day was devoted to further review of specific questions posed by the Committee attempting to understand various possible options that might be available to reduce or defer planned expenditures, which appeared to have grown approximately twofold since January 2004.

In seeking to understand the cost growth the Committee learned that new evaluations of the Booster and AGS indicated significant remedial work should be done on radiation-sensitive components to avoid operational risks to the RHIC program; that additional long-lead spare components such as magnets should be built in anticipation of radiation failures which are likely to occur based on past experience; that a new environmental evaluation exposing the full range of regulatory requirements resulted in a further unavoidable cost increase; and that costs for a Project Office had to be included. Beamline costs formerly included in the Experiment budgets were transferred to the AGS Upgrade, as was a large pre-operations item called Beam Development. These items, including indirect costs and contingencies, accounted for the cost growth.

The Committee concluded that the proposed scope of new work accounting for the increased budget requests was reasonable and clearly desirable. However, questions remained as to the absolute necessity of the full scope, and whether reduction in scope or deferment of some tasks in hopes of future funding was possible.

Only in the area of Beam Development was the Committee able to suggest a significant potential cost saving, namely reducing the planned time of this activity from five to two years, which the Upgrade team agreed was worth examining.

The Committee discussed a range of technical, cost, schedule and management issues and in this report makes general recommendations for further reviews of the still developing plans. The Committee specifically recommends that efforts toward the draft Project Execution and Project Management Plans include a more detailed and accurate assessment of the key technical risks; critical examination of the overall schedule; better analyses of cost risks through detailed bottom-up modeling; better personnel planning through completion of resource-loaded schedules; and a critical evaluation of availability of personnel to match the needed ramp-up. The Committee further recommends that all elements of the plan be subjected to future reviews to scrub technical content, costs and schedules.

Since overall project cost remains a major issue and threat to the project, the AGS Upgrade and Experimental Project Teams are challenged to collaborate on finding imaginative solutions to cost reduction.

Contents

1 Introduction

The Rare Symmetry Violating Process (RSVP) Project AGS Upgrade Review Committee was convened at DOE's Brookhaven National Laboratory on November 4-5, 2004. This committee was formed at the request of W. Willis, Project Director, and Jonathan Kotcher, Deputy Director and charged with assessing the proposed technical scope, cost, schedule and management of the AGS portion of the RSVP project, with particular emphasis on the problem of budget estimate growth since last reviewed by a DOE Lehman Committee in January 2004. (See Appendix A, Charge to the Committee).

The Committee comprised seven members with extensive expertise and experience in Accelerator and Beamline design, construction, operations and interfacing with experiments. Several Committee members have management roles in one or more of these areas. The membership is shown in Appendix B. The Committee Chair was R. Larsen, Assistant Director of the Technical Division at SLAC for Electronics, Power Conversion, Controls and Instrumentation.

The RSVP will use the Alternating Gradient Synchrotron (AGS) which currently serves as the injector for the Relativistic Heavy Ion Collider (RHIC) as well as serving fixed target experiments of the NASA Space Radiation Laboratory (NSRL). The National Science Foundation will totally fund RSVP's two experiments, KOPIO and MECO, from inception to eventual decommissioning and disposal, including the necessary modifications and extended operations of the AGS complex. The project is a line item currently awaiting approval in the Presidential budget. The inter-agency relationship including a management structure is defined by a Memorandum of Understanding (MOU) between NSF and the DOE Office of Science dated July 2004. The management structure is currently being organized and staffed.

Presentations and discussions were held over the two-day period. Although much work remains to complete the technical and management plans and estimates, the Committee was pleased to see demonstrated progress and the enthusiasm of the Project Team. The following sections document findings, observations and recommendations.

2 Summary Evaluations

2.1 Technical Issues

2.1.1 Booster

2.1.1.1 Findings

The Booster is a high radiation area due to the relatively large beam losses during injection and acceleration, resulting in shortened lifetime of components such as magnets, PFN kicker power supply capacitors and other electronic components. The high intensity experiments of the past have finished running and the booster currently sends protons or heavy ions to the RHIC at a much lower duty cycle so activation is currently low. A magnet currently fails in the ring about once a year with the high intensity running and these failures occur somewhat predictably in magnets that absorb the highest beam losses on injection and extraction. RSVP now proposes running in the interstices of RHIC operation at intensities of double that of prior running. This will accelerate the failure of certain machine components and, due to higher radiation activation of the housing and components, make personnel radiation exposure during repairs more difficult. The AGS project team proposes to mitigate these risks by:

- Manufacturing additional spare magnets and/or coils which are non-standard, expensive and require about a one-year lead-time;
- Rebuilding PFN pulsed kickers to eliminate aged damaged components;
- Rebuilding at least the damaged sections of the cable plant around the ring; and
- Preemptively replacing a few magnets that absorb the most beam power losses and historically have failed after long radiation exposure.

These measures are designed to fulfill the “No RHIC Impact” rule.

A number of other upgrades are also listed, very few of which pose an operational risk to RHIC. These are primarily to handle the higher peak currents up to 100Tppp for KOPIO; to increase the beam energy to 2 GeV/c; and to provide better RSVP operation, including better feedback, loss monitoring, current monitoring, VME controls and software. Significant costs are also involved in adding shielding caps to meet to keep contamination of ground water below regulatory requirements. Some other tasks are to address potential safety issues.

2.1.1.2 Observations

The Booster serves RHIC alternately with protons and heavy ions. The activation with the present running is relatively low compared with past high intensity running. The low activation of the machine presents a window of opportunity to make needed changes. The changes proposed are reasonable although details remain to be discussed. The tasks are not developed beyond conceptual designs and require further assessment of scope as well as more bottom-up detailed resource-loaded schedules. Some detailed observations are as follows:

- A failure rate of 1 magnet per year is expected by the C-AD managers.
- The PFN's for the F3 extraction kicker power supply and associated capacitors. bank have received significant radiation dose over many years of operation and are in need for replacement.
- Extraction septum magnet F6 has only 1 spare for the moment. Another spare is included in the RSVP WBS.
- Beam losses at injection are the most significant source of residual activation in the Booster. Activation is due to neutral hydrogen beam that is injected before the H^- stripping foil.
- The H^- stripping, which occurs in the upstream section of the C6 straight section is not 100% efficient, giving problems with the C7 main dipole magnet.
- To further reduce activation in the Booster, improvements to the beam dump and addition of a set of primary collimators to the B6 beam dump are planned.
- RF feedback is planned to compensate the high intensity beam loading and operate with greater stability.
- The Beam Loss Monitor system needs repair and upgrade
- A new wider bandwidth wall current monitor for the high intensity is planned.
- Safety policies at BNL require that groundwater activation cannot exceed 5% of the EPA drinking water limit, requiring shielding caps over critical beam loss areas of Booster and AGS.

2.1.1.2 Recommendations

Since the Committee is charged primarily with a technical proposal cost impact analysis, the following recommendations are suggested:

a. Perform a detailed survey of cable trays and cables, etc. to assess conditions that *must* be repaired for safety reasons. Refine cost estimates accordingly.

b. Assess risks of repair activities *causing* safety problems with "at risk" but still serviceable cables. Design plan to minimize costs of repairs while maintaining safety.

c. Consider the impact of limiting upgrades of those items specifically designed to make RSVP more convenient to operate, as opposed to *unable* to operate. Assess cost benefits in areas of controls, improvement of PFN kickers etc.

d. Assess impact on RHIC if magnet/ coil replacement plan is limited in scope. Compare with present status of backup and likely downtime if a magnet fails during present operation. Many magnets do not have backups. Work out ALARA repair scenarios for present vs. more highly activated conditions.

2.1.2 AGS

2.1.2.1 Findings

The AGS has a similar set of technical issues as the Booster although details vary. New items proposed to improve experimental beams for RSVP include new low ripple power supplies, some of which are needed due to higher current requirements, and redesign of kicker magnets. A number of desirable instrumentation improvements are included. Many of the changes do not impact RHIC; they are basically designed to improve systems for RSVP running. Additions to the systems are RF components and Kickers for the beam extinction schemes, critical to the experiments.

2.1.2.2 Observations

The experimental beams are challenging. MECO requires two 20Tp bunches at 1.35 μsec, 1 s cycle, with inter-bunch extinction of 1×10^{-9} or better; 1 mm focus; minimum 4 x 10^{20} (-0/+50%) protons delivered. The proton throughput of 40Tp/s is twice that previously achieved. The 10^{-9} extinction goal has not been demonstrated experimentally and will not be until early 2008 after the secondary beam RF kicker installation. Achieving the extinction goal must be considered a high technical risk. A contingency plan was not discussed.

KOPIO requires 100Tppp, 5.3 s cycle; slow extraction with micro-bunching of <300ps (σ) every 40 ns. The 100Tppp requires Booster injection improvements and energy upgrade to 2 GeV/c. The required micro-bunching was demonstrated in FY02. Extinction of 10^{-3} requires R&D involving the 25MHz extraction cavity and 100MHz secondary beamline cavity; ~10^{-5} was demonstrated with a 4.5MHz extraction cavity in FY04. The main risk elements are achieving the peak intensity and the extinction. Contingency plans were not discussed.

The RF systems at 25 and 100 MHz will need to be designed, constructed, and commissioned. The resources necessary to design the systems have not yet been identified, but are expected to take significant efforts of an RF engineer and support staff to implement. As such, the cost estimate (WBS 1.4.1.5.2 is $331K, WBS1.4.1.5.3 is $2,152K fully loaded) for this part of the project will need to be refined.

The high intensity beams that are the baseline for both experiments will require improvements to RF beam loading compensation. While the AGS has run close to the required intensities in past runs, the desired protons per pulse will exceed previous records. WBS 1.4.1.2.3 lists fully loaded costs of $766K for RF feedback, but very little detail is broken out in the estimate. This would suggest that the design of this system is incomplete and requires attention.

2.1.2.3 Recommendations

a. Since most of the Booster issues apply to the AGS, follow the recommendations of section 2.1.1.3.
b. For the RF and Feedback systems, refine the conceptual designs with appropriate experienced RF engineering, generate resource-loaded schedules and revise cost estimates.
c. Develop a contingency plan if the present plan fails to produce the required extinction performance.

2.1.3 Switchyard and Experimental Beams

2.1.3.1 Findings

The Switchyard changes include removing existing components that currently support beam switching or sharing; widening apertures of optical components for MECO's lower energy beam; mounting MECO in the A-Line and KOPIO in the B-Line;

relocating the RHIC e-cooling experiment (under construction) and NASA facility; decommissioning the D-Line (but leaving it possible to restore); and installing beam plugs so the area can be safely accessed while RHIC (or the MECO beam) is running. The NASA facility moves to another existing building already equipped with HVAC so there is minimal infrastructure cost. Only one new magnet may be needed, but new VME instrumentation and controls improvements and software are planned.

2.1.3.2 Observations

The Switchyard design (1.4.2): has been modified to accommodate the needs of the RSVP experiments. The new design removes components not needed that would cause losses and radiation concerns if left in place (ALARA). Radiation damage requires hot work and worker radiation, so reducing losses is a safety concern. The intensity increase and the lower 7.5 GeV/c energy for MECO leads to an increased emittance and need for larger apertures. Several magnets need to be rebuilt.

The layout has been changed to put the experiments farther apart with separate crane coverage. This should expedite the experiment and shielding installation.

The new design uses an achromatic optics to the target, making targeting insensitive to energy. This allows removal of the automatic beam steering controls and associated sensor instruments. Also removal of insertion flags, etc. eliminates need for upgrading systems including controls. The optics design is complete and current cost estimate reflects that design. Some detailed further observations are:

- The cost (WBS 1.4.2) of 5.8 M$ is new since Jan 04 review.
- Need utility upgrades planned in switchyard.
- Beam plugs allow access for installation/construction while AGS (or MECO) runs.
- AGS work scheduled during 6 month scheduled downtime.
- There are four new magnets; 20 existing ones get relocated.
- The new design requires new stainless steel vacuum chambers in the switchyard.
- The D line will be decommissioned, only removing components in the way for RSVP A and B lines. The shielding from D will be used for MECO.
- There are expected to be no technical or financial risks for the switchyard. There are minor schedule conflicts with crane usage.
- The 10^{-9} extinction is critical for the MECO experiment. The experiment is responsible for the external RF strip line magnet which is now in preliminary design. An engineering design and cost estimate is needed. The double method

for extinction (AGS and extraction line) is reasonable, given the importance of achieving the goal. However, as suggested in 2.2.3.1(c), a contingency plan is warranted.

- KOPIO: Shielding for experiments and detector pit are not base-lined. Production angle, aspect ratio of neutral beam, size of detector pit not finalized and all impact costs.
- MECO: Recommendations from recent SC magnet review are not reflected in current estimate. Target maintenance will be a challenge due need to remove from downstream end where radiation will be high. Interface between MECO solenoid procurement and handover to C-AD cryogenic operations needs to be worked out.

In summary, the Switchyard area work is extensive but most of it is a reduction of present equipment and relocation of beamline components as well as existing fixed target experiments. The plan seems well designed to secure the areas to be accessible while RHIC and the NASA NSRL continue to operate. Most of the work is low technical risk. Target servicing will be a challenging maintenance concern. It is very important that the production angle and beam aspect ratio be frozen before detailed design begins.

2.1.3.3 Recommendations

a. Freeze production angle, beam aspect ratio as soon as possible so detailed design can begin.

b. Continue design of Beam Development plan to optimize (minimize) cost impact.

c. Continue developing requirements for experiment interfaces so detailed conceptual design and resource-loaded schedules can proceed.

2.2 Cost

2.2.1 Findings

The Presenters explained that the cost increases in the estimates since January 2004 were primarily for the following reasons:

a. A more careful risk assessment of the AGS complex running with higher intensity beams resulted in recommending a large number of pre-emptive remediation measures to minimize impact on RHIC operation.

b. The Beam Development plan, formerly classified as a Pre-Operational cost, was added to the construction estimate.

c. Switchyard secondary beam costs formerly carried in KOPIO and MECO were transferred to AGS.

d. Staffing and supporting a Project Management Office were added.

The Committee found a large effort underway to complete the cost estimates and schedules, but these were not yet finalized. Schedules are only beginning to be resource-loaded and leveled. The Committee did not have time to delve into specific cost estimates but looked for high-level consistency and completeness.

Two areas that were discussed in more detail were the manpower planning for project ramp-up, and the reasons why Beam Development needed to be so protracted and costly. The first concern is how to rapidly employ qualified engineering at the beginning of the project. Engineering at many labs is being reduced due to retirements and layoffs and skilled engineers that could respond quickly are being lost. Designers are much easier to hire on a contract basis. This impacts costs in two ways -- by the longer learning curve for new inexperienced engineers, and the "standing army" costs of missed schedules. Historically, funding agencies often fail to deliver funding according to plan, causing projects severe cash flow problems with impacts on personnel and schedules. All projects face such problems but the present is an unusually challenging time to be seeking bridge financing from collaborator or host laboratories.

The Beam Development plan was challenged by the Committee as a very expensive plan with a goal that appears to go far beyond requirements, namely to produce fully qualified full power beams at the time experiments are first ready to turn on. The AGS team committed to reexamine the plan, possibly saving ~\$14M if the schedule were reduced by two years.

Operations costs starting in FY11 were also presented. Since the RSVP requires protons, the minimum incremental cost of RSVP running occurs when the AGS is delivering pp to RHIC. Costs increase somewhat with RHIC running HI mode, and roughly double when running alone without RHIC. Therefore costs fluctuate depending on RHIC beam delivery plans, but most dramatically if RSVP runs alone. The model presented showed 29 running weeks available, 10 of which were outside RHIC running. for at an average total cost of ~\$12M/year. The Common Costs/week for AGS and Linac are estimated at $106K with pp, $149K with HI, and $248K if running alone. RHIC is assumed to run a constant 27 cryo-weeks in this model but only 19 weeks of beam delivery, dropping to 15 weeks in the years FY13-16. During the entire period RSVP shows a constant 10 weeks outside of RHIC, so drops from 29 to 25 weeks running during this same period.

2.2.2 Observations

Cost reduction of the total AGS upgrade remains an over-riding issue. Inability to make substantial progress on this issue, as well as paying equal attention to cost issues in the experiments, is the single greatest risk to the program. The one suggestion agreed upon was to reexamine the duration – or need for – the Beams Development phase of the program.

The anticipated higher radiation exposure led to a considerably more expensive plan to preemptively replace components. Mitigating these risks necessitates a large capital outlay in order to have spares on hand of all critical tunnel components, including magnets, kickers, switchgear and any component that will cause what is currently seen as an unacceptable downtime if it fails. Moreover, and more problematical, once the machine is running at high intensity, removing and replacing a large component will quickly use up the available specially trained radiation workers. The magnets are large, somewhat unique and take up to a year to build. Other components such as kickers could in principle be redesigned for quicker replacement, or removed to a more protected area; either will be an additional expense that has not been estimated. Alternative impacts of a less aggressive preemptive replacement plan were not explored.

The lack of resource-loaded schedules presents both cost and schedule risks. Until these are completed and the costs and technical program elements examined by a review team, the precision of the estimates must be considered low, which should be reflected in the budget contingency. Although much of the proposed upgrade is indeed low technical risk (rebuilding known components, repairing/replacing cable plant), included are new designs or redesigned elements which bring additional cost and schedule risk. The contingencies shown of ~22-24% are typical of more mature cost estimates.

The Committee charted the total list of proposed tasks in **Table 2.2-1** (Ref: K.A. Brown, AGS/Booster/Switchyard Modifications and RSVP Beam Implementation).

	A	B	C	D	E	F	G	H	I
1	**Ref.**	**Category**	**Proposed Work**	**Comments**	**RHIC Ops**	**Safety/Env**	**Helps**	**RSVP Ops**	**Cost**
2					**Essential**	**Essential**	**ALARA**	**Essential**	**Estimate**
3	**BOOSTER**								
4	3.1.1	Infrastructure	Cable tray possible damage	Safety review needed	No	Maybe	Yes	No	
5	3.1.2	Electrical	Cable damage some areas	Safety issue in some areas	No	Yes	Yes	Yes (Safety)	
6			Build spare magnet coils etc.	Failures will accelerate	No (MTTR)	No	Yes	No	
7			Redesign F3 Extract kicker	Reliability, access issue	No (MTTR)	No	Yes	No	
8	3.1.3	Mechanical	F6 Extract septum spare	High risk to all expts	No (MTTR)	No	Maybe	Maybe	
9			New H- Stripping foils	Reduce C5,C7 activation	No (MTTR)	No	Yes	No	
10			New B6 BD collimators	Needs study	No	No	Yes	No	
11	3.1.4	RF	Band III + Band II Feedback	Improve beam for RSVP	No	No	No	No	
12	3.1.5	Instrumentation	Loss Monitor Upgrade	Needs to work reliably	No	No	Yes	No	
13			New Wall Curr.Mon + DAQ	Higher BW improves stab.	No	No	No	No	
14			New C3 Inflector protection	Used in HI injection	Yes	No	No	Yes (Safety)	
15			Replace rad damaged cables	Fire/safety hazard	No	Yes	No	Yes (Safety)	
16			Gain switch mods to BTA	Needed RSVP	No	No	No	No	
17	3.1.6	Controls	Add VME interfaces, softwre	Maintainability issue	No	No	No	No	
18	3.1.7	Safety/Environ	5% Caps over soil shielding	Regulatory reqmt	No	Yes	No	Yes (Safety)	
19	**AGS**								
20	3.1.8	Infrastructure	Cable tray possible damage	Safety review needed	No	Maybe	Yes	Maybe(Safety)	
21	3.1.9	Electrical	Cable damage some areas	Safety issue in some areas	No	Yes	Yes	Yes(safety)	
22			Build spare magnet coils etc.	Failures will accelerate	No (MTTR)	No	Yes	No	
23			New active filter magnet PS	Improve ripple	No	No	No	No	
24			New low ripple PS F5,F10	Slow extraction needs	No	No	No	No	
25			New low ripple PS BD J10	Improve beam spill ripple	No	No	No	No	
26			Redesign A5 Injection kicker	Reliability, access issue	No (MTTR)	No	No	No	
27	3.1.10	Mechanical	Redesign F5, F10, H20	Incr. apertures	No	No	No	Maybe(Intensity)	
28			Improve grounding, EM shldg	Lower AGS Z	Maybe	No	No	Maybe(Intensity)	
29			Replace 16 more sextupole coils	Cannot support high intensity	No	No	No	Yes(intensity)	
30			Add collimators	May help ALARA	No	No	Maybe	No	
31	3.1.11	RF	No issues						
32	3.1.12	Instrumentation	Loss Monitor Upgrade	Needs to work reliably	No	No	Yes	No	
33			New Wall Curr.Mon + DAQ	Higher BW improves stab.	No	No	No	No	
34			Move IPM gas leak servo cntrls	Susceptible to rad damage	No	No	No	No	
35			Replace mover motion controls	Old, "adversely affects RSVP'	No	No	No	Maybe	
36			Add high-rad resistant cameras	Old, "adversely affects RSVP'	No	No	No	Maybe	
37			Replace rad damaged cables	Fire/safety hazard	No	Yes	No	Yes (Safety)	
38			Upgrade ring ground monitoring	"Will seriously affect RSVP."	No	Maybe	No	Maybe(safety)	
39	3.1.13	Controls	Add VME interfaces, softwre	"Un-maintainable"	No	No	No	Maybe(Intensity)	
40			Add VME PS interfaces, softwre	F5,F10,H20, J10, active filters	No	No	No	Maybe	
41	3.1.14	MECO Mods	Add Vert Dipole, Stripline kicker	Extinction scheme	No	No	No	Yes	
42	3.1.15	KOPIO Mods	Add 25,100MHz cavities	Microbunch scheme	No	No	No	Yes	
43	3.1.16	Beam Devmt	Beam tests constr phase	Meeting beam specs critical	No	No	No	Yes	
44	**AGS SWITCHYARD**								
45			Remove beam splitters	No need for split beams	No	No	No	Yes	
46			Mount MECO in A-Line	8 GeV/c beam	No	No	No	Yes	
47			Mount KOPIO in B-Line	25 GeV/c beam	No	No	No	Yes	
48			Relocate NSRL (A3 beam)		No	No	No	No	
49			Move RHIC e-cooling expt		No	No	No	No	
50			Decommission D-Line	Use parts for new lines	No	No	No	No	
51			Make D-Line restore plan	Option to restore in future	No	No	No	No	
52			Redesign beam optics	Elim SWICs, ramped dipoles	No	No	No	Yes	
53			Install beam plugs	Isolate safe areas for // work	No	Yes	Yes	Yes	
54	**AGS NASA FACILITY**								
55	3.1.17	Design	Complete Detailed Design	Conceptual only done	No	No	No	No	
56	3.1.18	Shielding	Minor mods needed		No	No	No	No	
57	3.1.19	Vacuum	Add windows, elim flanges	welds replace some flanges	No	No	No	No	
58	3.1.20	Electrical	Minor load adjustments	Load reduced from xstg sys.	No	No	No	No	
59	3.1.21	Mechanical	Eliminate moveable magnets	Only BD4 may be new	No	No	No	No	
60			Add collimators to elim halo		No	No	No	No	
61	3.1.22	Instrumentation	Simplify flags instr'n		No	No	No	No	
62			Reduce beam loss system~1/2	Some repair needed	No	No	No	No	
63			Minimize plungers	Simplify mechanics	No	No	No	No	
64	3.1.23	Controls	Add VME interfaces, softwre		No	No	No	No	
65			Add VME PS interfaces, softwre	RepalceDatacon	No	No	No	No	
66			Add database to controls		No	No	No	No	
67	3.1.24	Infrastructure	Use existing buildings w/HVAC	Minimal cost	No	No	No	No	
68	**SAFETY & ENVIRONMENTAL PROTECTION**								
69	3.1.25	Access Controls	Instrument Switchyard w/PASS	Standard Personnel system	Yes	Yes	Yes	Yes	

Table 2.2-1: AGS Upgrade Task Summary

Alongside the tasks are columns showing (in the Committee's interpretation) whether the task is:

a. Essential for RHIC Operation

b. Essential for Environment or Safety

c. Helpful to ALARA

d. Essential for RSVP.

The chart is intended to suggest a way of identifying absolutely essential from less critical tasks, such as improving MTTR, which might be de-scoped or deferred, and if determined to be necessary later, addressed incrementally in future operating budgets.

The total project cost presented includes operating costs out to CY2018. Running at lower beam intensity for longer than already scheduled poses potential loss of the discovery physics to competing experiments. This argues for a more aggressive schedule and shortened overall duration. Operating the experiments' detectors more hours outside of RHIC increases costs per hour, but also would shorten duration and total cost as long as the detectors could handle the higher data rates. This point was not explored.

Environmental requirements and safety must be accorded a top priority. Since RSVP is completely responsible for the remediation and eventual decommissioning and disposal, a significant cost has been added for this work since the January 2004 review. However it is not clear how tightly constrained the proposed remediation program of radiation caps, etc. is, and whether lower-cost solutions are possible.

Currently RHIC operation is planned to increase from 50% to 60% of current clock time (which does not include planned annual downtimes), so the available time for AGS upgrades would shrink proportionately. Increased RHIC operating time concurrent with RSVP operations is a benefit.

The AGS schedule depends on the experiments keeping on their construction schedule; slippage in the latter will impact the AGS personnel and run-time costs for commissioning. High technical and schedule risks in the experiments need to be factored into AGS contingency planning.

2.2.3 Recommendations

Consider the following cost reduction possibilities:

a. Organize detailed Cost scrubbing reviews of all Booster, AGS and Switchyard major components as soon as feasible.

b. Consider Table 2.2-1 to suggest possible deferment or later staging of portions of proposed upgrade plan with possible later addition as needed during operations.

c. Freeze detector locations, parameters, collimating devices as soon as possible to minimize engineering costs.

d. Consider cost models constraining RSVP to (i) only RHIC operation; (ii) inside or outside RHIC operation to finish total experimental schedule as rapidly as possible.

e. Consider if KOPIO can be designed to use some or all of existing nearby pit.

f. Explore if BNL laboratory funds may legitimately be used to offset some of the AGS/ Booster reliability improvements.

g. Consider shortening the beamline commissioning (Beam Development) program if necessary at cost of lower quality beams during initial 1-2 years.

2.3 Schedule

2.3.1 Findings

The overall schedule shows the bulk of the AGS modifications accomplished between 2006 Q2 and 2008 Q3; the all-important beam extinction measured in the AGS in 3/2007 and 3/2008; the MECO Engineering run in 2008-9 and Data run in 2009-10; and KOPIO Engineering and Data runs in 2009 and 2010. The proposed beam allocation for operations shows MECO and KOPIO sharing approximately equally the available beam time for the first four years, FY11-14, at which point MECO finishes and KOPIO takes all available beam from FY15-18.

Detailed schedules that show the sub-tasks and analyses of skills needed versus time, i.e. resource loading, have barely begun.

2.3.2 Observations

Until schedule details are more developed it is difficult to comment on both cost and schedule risk factors that may appear later. Project Management has to rely on the experience of the AGS team in making expert forecasts without the detailed analyses. With the very large number of sub-tasks, some highly interdependent, a detailed schedule showing the interdependencies and resource loading is urgent for further progress. Meanwhile, appropriate cost contingency should cover the schedule cost risks.

The 4-5-year schedule for Beam Development has already been mentioned as an activity that might be considerably shortened for cost considerations.

A more aggressive overall schedule may improve total project cost, particularly if the Opportunity Cost of an idle machine is considered. This is the total operating budget plus a portion of the capital cost amortized over the useful lifetime of the machine, e.g. 20 years. For example, a $500M machine complex with a $100M/yr operating budget would have an Opportunity Cost of ~ $15,000/hr. The simple message is, these are very expensive machines so let's keep the productivity high. Idle machinery and people are a poor investment. Therefore, even though running outside of RHIC is more expensive than running concurrently, the fact that RHIC uses only half the available calendar time is a strong incentive to explore scenarios that will shorten RSVP time to completion.

2.3.3 Recommendations

a. Investigate ways to achieve an accelerated, significantly shorter commissioning and experimental operating schedule. Consider both Life-Cycle and Opportunity Costs.

b. Investigate reducing the execution time of the AGS Upgrade by (i) an accelerated development program, and (ii) reducing scope wherever possible to minimize time to completion of installation and commissioning. Consider supporting planned incremental upgrades on an as-needed basis during future operational downtimes to reduce costs.

2.4 Management

2.4.1 Findings

The Committee received a presentation on the management structure for the overall RSVP that was developed in the Memorandum of Understanding between DoE and NSF. The RSVP is organized by the Project Director and Deputy, and consists of three main branches for the AGS and the KOPIO and MECO experiments. The AGS section consists of sub-sections for Booster, Switchyard, MECO beamlines, KOPIO beamlines, and the Project Office. Leadership is identified for the head section and all sub-sections. The entire RSVP reports to a Joint Oversight Group with NSF, DOE NP and HP, and NSERC representatives. It also reports to BNL Laboratory management and to DOE and NSF funding agencies.

The manpower plan for project execution depends heavily on a matrix of existing laboratory resources augmented with new hires and contracts as needed. Since the project calls for a relatively fast start, the acquisition of skilled manpower in a timely manner, especially engineering, is a concern, especially since BNL is in process of reducing its engineering force. The less experienced the people who are acquired the longer the learning curve and the slower the startup will be, impacting both schedules and costs.

The basic project management organization appears to be functional but clearly, as expected at this stage where funding has yet to be approved, is thinly staffed. Regular meetings both dedicated to RSVP matters and integrated with RHIC operations and planning are already routine. The team clearly has the basic leadership expertise and experience for the tasks it proposes. The main worry is where to get the needed critical engineering skills for the fast ramp-up.

The existing management is experienced in the matrix mode of operation and appears confident that all these problems are solvable. However, some factors are not easily controlled regardless of the skills of management. The AGS project will depend chiefly upon BNL resources for startup, which it must; but the broader the range of upgrades it proposes, the more that skilled manpower becomes an issue. The AGS Upgrade alone is currently estimated as an ~$85M project spanning four years; and as pointed out above, manpower planning derived from reasonably detailed resource-loaded schedules has just begun.

2.4.2 Observations

Impressive progress in developing the AGS Upgrade Plan has been made since August. However, the effort is limited by the fact that the project is still in a conceptual design stage with no funds approved (as of November 5, 2004) for new hires. The key elements pacing approvals are those called out by Lehman in January 2004, namely the Project Execution and Project Management Plan drafts to be approved along with the new MOU. That this is incomplete is an indication of the limited manpower available for the critical planning that will decide and secure approvals of the final program. In view of past delays and anticipated further delays, new resource-loaded schedules should be updated to reflect realistic milestones and resource ramp-up.

The Project Office is a crucial activity which appears to have token funding in the proposal, carrying about 1.5 FTEs. This is inadequate to execute the full scope of responsibilities for a Project Office for a project this size unless there is other manpower coming from another funding source. The task requirements and needed resources for this office need to be established as rapidly as possible. Among the resources needing to be quantified are those for selecting and maintaining the cost estimating and tracking tools, as well as those for project-wide engineering standards, design review, quality control, communications and coordination. The successful completion of the Project Execution and Project Management Plans depend heavily upon resources from this group.

The scheduled ramp-up in 2006 appears in jeopardy unless the overall plan is approved in the next six months.

2.4.2 Recommendations

a. Complete drafts of the Project Execution and Project Management Plans including an accurate assessment of the key technical risks, realistic analyses of cost risks through detailed bottom-up modeling, realistic personnel planning across the board aided by resource-loaded schedules, and a critical evaluation of availability of personnel to match the needed ramp-up.

b. Once the draft plans and supporting work are complete, the RSVP project managers should organize reviews to strongly focus on technical justification, cost and schedule scrubbing of overall system scope and key subsystem components, particularly those requiring R&D.

c. RSVP management needs to challenge the entire RSVP Team to explore together imaginative ways to eliminate, reduce or defer construction costs. Some possibilities are:

  - Constrain proposed upgrades to items vital to meeting the RSVP minimum beam requirements and non-interference with RHIC.
  - Explore deferment of changes that are designed mainly to minimize MTTR for RHIC, such as stocking of magnet spares, replacement of controls systems, redesign of kicker magnet drivers, etc. to later "as needed" repairs or upgrades.
  - Explore a future operating fund set-aside for repairs on an as-needed basis.
  - Significantly reduce or eliminate Beam Development proposal designed to prepare beams for maximum levels on Day One of experimental engineering and data runs.
  - Explore global changes to plan to reduce life-cycle costs such as more rapid completion of MECO while initially delaying KOPIO; buying more running hours earlier to accelerate completion of MECO without beam sharing with KOPIO; buying more running hours later to accelerate KOPIO completion.
  - Consider capital costs, operating costs, Life-Cycle costs and (lost) Opportunity costs in all scenarios.

3. Conclusion

The RSVP is an exciting, challenging physics project with the highly desirable feature of making use of the existing lightly loaded AGS infrastructure. Obviously from a cost standpoint the experiments could not be contemplated without the valuable resources of the BNL infrastructure and its talented, experienced staff.

At the same time, it must be recognized that the experiments must be proven feasible to construct and operate within the many constraints imposed by RHIC, the proponents, collaborators, physics and engineering staffs, and funding agencies, offices and personnel. Solving these problems may not be as technically difficult as the physics, but it is every bit as crucial and challenging in its own right. Solving these problems in a timely manner demands the best efforts of the technical as well as the managerial staff.

The RSVP team seems well on its way to completing a successful project plan, assembling the resources and making the difficult choices to assure cost and schedule control in the execution. The Reviewers are confident that the full RSVP collaboration will appreciate the challenges at hand and rise to meet them.

Respectfully submitted,

Ray Larsen, SLAC, Chair

For the AGS Upgrade Review Committee:

Stanley D. Ecklund, SLAC
Alberto Marchionni, FERMILAB
Gerald McMichael, ARGONNE
Elias Metral, CERN
Ralph J. Pasquinelli, FERMILAB
John Seeman, SLAC

4.1: Charge to the Committee

Review of AGS Upgrade and Operations Program for RSVP
Brookhaven National Laboratory
November 4-5, 2004

CHARGE TO THE COMMITTEE

[1] Review all elements of the proposed AGS Upgrade Construction Program for RSVP through presentations by the design team. Team should present:

- Essential aspects of the plan, including the proposed scope that has been verified with RSVP experimental teams;
- Upgrade implementation plan, including resource loaded schedule;
- As clearly identified and separately estimated, any non-RSVP elements of the proposed plan;
- Technical, schedule and cost risks to the plan.

[2] Review the proposed Operations Plan for RSVP, including plan and resource-loaded schedule; potential conflict with non-RSVP operations and vice-versa.

[3] Examine the management structure of the AGS Upgrade Program for RSVP, including line authorities in the Brookhaven Laboratory and RSVP management. Is there sufficient integration, interaction, communication, etc.? Are responsibilities clear?

[4] Explore with the design team possible reductions in scope, deferment, or future staging of elements of the proposed upgrade. Identify and characterize attendant risks and trade-offs associated with each of these changes. Explore all issues of joint concern to AGS, RSVP teams.

[5] Summarize findings and recommendations in final closeout report.

4.2: Committee Membership & Observers

Members:

Stanley D. Ecklund	Accelerator Physicist, Stanford Linear Accelerator Center
Ray Larsen (Chair)	Electrical Engineer, Asst. Dir. Technical Division, SLAC
Gerald McMichael	Accelerator Physicist, Argonne National Laboratory
Elias Metral	Accelerator Physicist, CERN
Alberto Marchionni	Accelerator Physicist, Fermi National Laboratory
Ralph J. Pasquinelli	Electrical Engineer, Head RF Dept, Fermi National Laboratory
John Seeman	Accelerator Physicist, Head Accelerator Department, SLAC

Observers:

Michael Butler, PMP	Project Manager, US Department of Energy, Brookhaven Area Office
Dr. Alexander Firestone	Columbia University, RSVP Project Office
Dr. Marvin Goldberg	Program Manager, National Science Foundation
Dr. Jehanne Simon-Gillo	Acting Director, Facility and Project Management Division, US Department of Energy
Dr. Thomas Kirk	Head, RSVP Laboratory Oversight Group; Associate Director, Brookhaven National Laboratory

4.3: Review Agenda

AGS RSVP Review			
Brookhaven National Laboratory			
Large Seminar Room, Instrumentation Building, Bldg. 535			
November 4-5, 2004			
Thursday, November 4			
	Presenter	**Minutes**	**Time**
Executive session		60	8:00
Welcome and introductions	Chaudhari	10	9:00
AGS RSVP Upgrades - Overview	Pile	45	9:10
RSVP Safety and Environmental Issues	Lessard	15	9:55
Coffee Break		15	10:10
Upgrade Technical Presentations I: AGS, Booster & Switchyard			
AGS/Booster/Switchyard Modifications and RSVP Beam Implementation	Brown	45	10:25
AGS/Booster - RSVP Mechanical Issues	Tuzollo	15	11:10
AGS/Booster - RSVP Electrical Issues	Sandberg	15	11:25
Upgrade Technical Presentations II: Experimental Areas & Beams			
K0PI0 Infrastructure			
(target, primary & neutral beam, utilities, buildings, etc.)	Pearson	30	11:40
MECO Infrastructure			
(target, primary beam, muon beam support, utilities, buildings, etc.)	Phillips	30	12:10
Lunch		60	12:40
Upgrade Technical Presentations II (cont'd)			
Beam Development & Pre-Operations	Roser	30	13:40
Upgrade Construction Schedule and Personnel Issues	Pendzick	30	14:10
RSVP Operations and D&D	Pile	30	14:40
Coffee Break		15	15:10
Upgrade & Operations Cost & Schedule Summary	Pile	40	15:25
Management Issues	Pile	20	16:05
Executive session		90	16:25
Questions to Presenters		30	17:55
Adjourn			18:25
Dinner at Berkner Hall			18:30
Friday, November 5			
	Presenter	**Minutes**	**Time**
Answers to yesterday's questions	As needed	120	8:00
Coffee break		15	10:00
Open discussion of all issues with AGS, RSVP Teams			
Discuss possible action items		120	10:15
Lunch		60	12:15
Executive Session-Prepare Draft Reports		165	13:15
Closeout			16:00

4.4: Questions to Presenters

1) There are major concerns about cost growth. What plan can you now come up with to reduce cost, or defer costs with plan for future upgrades?

2) Have you seriously looked at possible staging scenarios? Deferrals, with later funding? Can you reduce Beam Development by 2 years, delaying tests, saving $ and drop the year of contingency?

3) The AGS-Specific question:
What costs have changed since January 2004, broken out by WBS? What has moved around, what scope has changed, and what has increased in cost?

4) Scrubbing (checking validity) of existing estimates: Which ones? Should the team have a Lehman review?

5) Have you had experience removing and replacing cable plant? Costs, risks, disposal?

6) What can you do for 50 M$ for WBS 1.4.1?

7) What is impact to MECO experiment of not reaching 10^{-9} extinction goal, say by a factor of 10?

8) What is impact of not reaching 100 Tppp for KOPIO?

4.5: Individual Reviewer Comments

The following comments collected from individual committee members prior to the Closeout discussions are included for completeness:

Ralph J. Pasquinelli, Fermilab

General Comments:

The presentations were informative and described the proposals for modifications for the accelerator and switchyard portion of the RSVP project at BNL. Due to the short duration of the review, presentations did not go into extensive technical detail, but listed most of the major tasks associated with the upgrade of the AGS complex. The review committee was charged with the task of understanding the costs and attempting to find ways to reduce the expenditures without de-scoping the project.

During the course of the presentation portion of the review, it became evident that there were no areas where the BNL staff felt comfortable with cuts in the program. To be specific:

- Elimination one of the two distinctly different physics experiments (an obvious choice for cost reduction) is believed will kill the entire proposal.
- The operation schedule for the accelerator complex including RHIC does not allow for extending annual running periods. Running more weeks per year would add costs to RSVP operations and is only a savings over the option of running RHIC with polarized protons. (Operation of RSVP with RHIC in heavy ion mode is equivalent to running RSVP alone in terms of protons delivered per dollar.)
- Reduction of intensity to the experiments of even a factor of ten presents problems with cosmic background levels for one of the experiments. The proposal is to run the injector complex at a rate that is 1000 times higher than that needed for RHIC operations. A tenfold increase in intensity will yield a radiation dose making the proposed modifications to the aging injector more costly in the long run.
- Reducing the duty cycle would extend the running period of the experiments and increase costs.
- Reducing the staff would not allow for efficient round the clock operations.

The plan includes a five-year Beam Development period (plus a year contingency), which is intended to re-commission the accelerator complex to a level that would be comparable to the high intensity running of previous AGS performance. The upgrades include new kickers and RF systems, but most of the cost is in infrastructure improvements to the aging machines. The first year utilizes only 9 weeks of running and the second year, 11 weeks. This does not seem aggressive. Shortening the commissioning is one area where costs cuts could be achieved, but may amount to only 20% at best.

Due to the low AGS intensity operation required for RHIC over the last two years, the injector complex has been "cooling off" from radiation exposure received during the last high intensity run in 2002. This is a unique opportunity to fix the aging infrastructure that is required to operate the slow spill fixed target mode necessary to run KOPIO and MECO. The presentations for the upgrade appeared to be sound. Certainly the photos shown indicated clearly that improvements should be made to make the injector complex more robust and hence, present little risk to RHIC operations while running the two new fixed-target experiments. It would not be prudent to ignore modifications to the AGS and booster. Re-examination of the scope of the upgrades is in order to obtain a more accurate cost estimate. Contingencies associated with the improvements are at a level of 22-24%, which is consistent with a strong level of confidence in the proposed scope of the work.

The project is expected to begin in FY06, which at this stage seems optimistic. Costs have increased $30 million for the AGS portion of the project since the beginning of 2004. This is due mainly to the examination and inclusion of injector modifications in the proposal. This increase, while not an exact cost, is warranted and important to the success of the endeavor. The cost for the accelerator and switchyard portion of the project is now estimated at $85 million. Although not presented in detail, each of the experiments has a commensurate cost estimate making the total costs (considerably higher than the President's budget request of) $150 million. In an effort to put a cap on costs, the project will need to establish a project management team whose duty will be to create a strong justification for the escalating costs. Failure to do so could jeopardize the success of the project.

The presenters did a commendable job in preparation for this review. It was evident that a significant step up in attention to the details of the injector complex improvements has been given priority since the beginning of the year. With escalating estimated project costs, more detailed reviews should be expected before project funding approval. This will require a significant increase in the investment of people and resources in the preparations for the project.

RJP Comments on RF Issues:

The KOPIO experiment requires the AGS to support "micro bunching" of the beam. RF systems at 25 and 100 MHz will need to be designed, constructed, and commissioned. The resources necessary to design the systems have not yet been identified, but are expected to take significant efforts of an RF engineer and support staff to implement.
As such, the cost estimate (WBS 1.4.1.5.2 is $331K, WBS1.4.1.5.3 is $2,152K fully loaded) for this part of the project will need to be refined.

The high intensity beams that are the baseline for both experiments will require improvements to RF beam loading compensation. While the AGS has run close to the required intensities in past runs, the desired protons per pulse will exceed previous records. WBS 1.4.1.2.3 lists fully loaded costs of $766K for RF feedback, but very little detail is broken out in the estimate. This would suggest that the design of this system is incomplete and requires attention.

Stanley D. Ecklund, SLAC

General Comments:

The Switchyard (1.4.2): has been modified to accommodate the needs of the RSVP experiments. The new design removes components not needed and would cause losses and radiation concerns (ALARA). Radiation damage requires hot work and worker radiation, so reducing losses is a safety concern. The intensity increase and the lower 7.5 GeV energy for MECO leads to an increased emittance and need for larger apertures. Several magnets need to be rebuilt.

The layout has been changed to put the experiments farther apart with separate crane coverage. This should expedite the experiment and shielding installation.

The new design uses an achromatic optics to the target, making targeting insensitive to energy. This allows removal of the automatic beam steering controls and associated sensor instruments. Also removal of insertion flags, etc. eliminates need for upgrading their systems including controls. The optics design is done and current estimate reflects that design.

- The cost (WBS 1.4.2) of 5.8 M$ is new since Jan 04 review.
- Need utility upgrades in switchyard.
- Beam plugs allow access for installation/construction while AGS (or MECO) runs.
- AGS work during 6 month scheduled off.
- There are four new magnets, 20 are existing ones which get relocated.
- The new design requires new stainless steel vacuum chambers in the switchyard.
- The D line will be decommissioned, only removing components in the way for RSVP A and B lines. The shielding from D will be used for MECO.

There are expected to be no technical or financial risk for the switchyard. There are minor schedule conflicts (with crane usage).

The 1E-9 extinction is critical for the MECO experiment. The experiment is responsible for the external RF strip line magnet which is now in preliminary design. An engineering design and cost estimate is needed soon. The double method for extinction (AGS and extraction line) is reasonable, given the importance of achieving the goal.

SDE Comments on Experiments:

K0PI0

- Water jacketed target is similar to g-2 target, may use TRIUMPH design. 100 TP/s goal.

- Sweep magnets 3 T-m, ALARA, mineral insulation,
- Shielding for experiment is not base-lined.
- Use Conditioned cooling water for equipment.
- Detector pit not base-lined; size may change as experiment design changes.
- Six months design effort needed after base-lined.
- Major decisions need to be finalized:
  - Production angle
  - Aspect ratio of neutral beam
  - Size of detector pit (tried to cover in contingency)

    { Design effort is not included in WBS, getting to base-line in pre-project number. }

MECO

- Temporary beam stop needed to measure extinction while detector is being built.
- Expect to replace the target about once a year, from downstream end. Downstream end of vacuum chamber is in the WBS 1.4.
- Recommendations from recent SC magnet review not reflected in current estimate.
- Target maintenance will be a challenge due need to remove from downstream end where radiation will be high.
- Interface between MECO solenoid procurement and handover to C-AD cryogenic operations needs to be worked out.

<u>*John Seeman, SLAC*</u>

General Comments:

The committee was pleased to see the good progress on the overall project design and cost estimate. The scope and extent of the technical issues seem to be in hand.

Several technical scope changes to the RSVP sub-projects have led to cost increases over the past few years. Examples of these changes are moving the location of the experiments, new switchyard beam line layout, and increased beam intensity. Project activities missing in the early estimates have also been added to the present new cost estimate.

The committee encourages the near term technical and cost reviews of the three parts of RSVP that will happen over the next few months by BNL management.

The detectors may not be able to handle the full beam power at start up in FY2010. The project should consider delaying commissioning to match the expected beam conditions permitted by the detectors during the early operation of RSVP.

The testing procedure of magnet coils by high potting should be revisited to see if the procedure and risk management of operation is optimized.

Cost reduction possibilities:

1) Detector parameters should be frozen ASAP to minimize additional engineering costs.
2) The collimating devices should be defined as soon as possible to reduce costs.
3) RSVP should not be run outside of RHIC running time to reduce yearly costs.
4) If KOPIO could use the existing nearby pit, it may reduce costs.
5) The peak beam current of RSVP could be defined as that of the AGS parameters of two years ago. It is likely that this would reduce development costs if the experiments can accommodate the change.
6) Existing laboratory funds may possibly be used to offset some of the AGS/ Booster reliability improvements.
7) Starting the commissioning of the accelerator a few years later may reduce costs although this may increase the risk of lower quality beams in the initial running years.

The following items increase project risk:

1) The Booster and AGS coil replacement may have a larger scope if the failure rates increase.
2) The cable tray cleanup may expose a larger hidden problem.
3) Putting new cables over old ones in the cable trays may cause new unknown problems.
4) The higher the needed beam current the larger the technical risk.

<u>*Alberto Marchionni, Fermilab and Elias Metral, CERN*</u>

General Comments:

Two experiments are involved in the RSVP project, MECO and KOPIO, both requiring high-intensity slow-extracted beams. They are two main challenges for MECO:

(1) The beam flux has to be increased by a factor 2 compared to the AGS record

(2) The beam extinction between bunches has to be at the level of 10^{-9} ($10^{-6} – 10^{-7}$ have been reached in short tests)

The main challenge for KOPIO is to reach 10^{14} ppp, i.e. ~30% *more than* the AGS record. The total integrated intensity required by the two experiments is $13*10^{20}$ (9 for KOPIO and 4 for MECO), which is about a factor 2 higher than what has been accumulated since the commissioning of the BOOSTER.

Beam losses are a major concern in both the Booster and AGS machines in order to be able to keep hands-on maintenance. One area of concern is aging cable and cable trays in the tunnels.

Booster

- A failure rate of 1 magnet per year have been expected by the C-AD managers
- The PFN's for the F3 extraction kicker power supply and associated capacitor bank have received significant radiation dose over many years of operation and are in need for replacement
- Extraction septum magnet F6. There is only 1 spare for the moment. Another spare is included in the RSVP WBS
- Beam losses at injection are the most significant source of residual activation in the Booster => Activation due to neutral hydrogen beam that is injected before the H^- stripping foil
- The H^- stripping, which occurs in the upstream section of the C6 straight section is not 100% efficient => Problems with the C7 main dipole magnet
- To further reduce activation in the Booster => Improvement to the beam dump + addition of a set of primary collimators to the B6 beam dump
- RF feedback to compensate with high intensity and operate with greater stability
- Beam loss monitor system is old and needs repair and upgrade
- A new wall current monitor for the high intensity
- Safety : New policies at BNL require that groundwater activation cannot exceed 5% of the EPA drinking water limit => in order to meet this requirement water impervious covers (called caps) over the shielding covering the accelerator tunnels (Booster + AGS)

AGS

- Improving the main magnet ripple requires a new active filter power supply
- There are 3 devices used in the extraction process: an electrostatic septum, a thin magnetic septum (F5) and a thick magnetic septum (F10) => Critical components for the slow extraction for RSVP => New low ripple power supplies required; do not have sufficient aperture for high intensity RSVP beams.

Switchyard

- MECO will be situated in the A-line (7.5 GeV/c beam) KOPIO will be situated in the B-line (25.5 GeV/c beam)
- The switchyard is simplified to be as robust as possible (only 1 experiment at a time, i.e. no PPM operation for the experiments, as these are almost DC magnets in the lines)
- Collimators to remove large amplitude particles and beam halo

All the proposed modifications look reasonable.

Concerning machine development, there are essentially two issues raised. The first (most important) is connected to the 10^{-9} extinction required by MECO. If not reached it kills the project. The second is to improve the high intensity. The high intensity on day 1 is not essential but if not reached fast, it may lead to unacceptable delays (in the present most optimistic scenario => ends in 2018.)

Gerald McMichael, Argonne National Laboratory

General Comments:

The plan that was presented called for four years of beam development (06-09) followed by one year (10) of beam operation for detector engineering. A year of contingency was included to allow for a possible delay in the construction schedule. Total cost was just over $32M.

We recommend that the project consider dropping the first two years of the plan plus the contingency year. This would reduce the cost to $18M, a savings of $14M. This would somewhat increase the risk that full beam intensity may not be available at the beginning of the detector engineering year. It may also mean that Beamline "D" would not be available for beamline development. We believe that the risk is acceptable and suggest that it may be possible to make a temporary hookup of beamline D if it would benefit the project in FY08.

GMcM Post-Meeting Comments:

There might be an alternative to the deletion of the first two years of beam development proposed above. In the "Upgrade and Operations Cost & Schedule Summary" presentation, (it was) said that without base support, short runs on the AGS are costed on a per-hour basis (page 9 of the presentation). Therefore it maybe possible and desirable to do some short runs to check some of the extraction physics and extinction ratios in year one or two (while beamline "D" is still available) for a lot less than the $8.5M of the proposal we were shown. (I'm not convinced) that they really need the two solid years of running in years 3 and 4 for beam development, given that they are not extending that far from what they have achieved before. It is likely that they will run for a few days at most, realize they must make changes (to magnets, controls, whatever), and then spend days or weeks making those changes before running beam again. If this is the case, then it may also be possible to reduce the 3rd and 4th year costs significantly.

We were not given any details of the beam development program, other than a plan to operate up to 30 weeks in years 3 and 4. Once they are in production mode with finished instruments, then it makes sense to run as many weeks per year as funds and personnel allow.

However, until then, we should recommend (designing) a detailed beam development program that uses intermittent running and takes maximum advantage of RHIC operation in order to minimize the incremental costs. At the time of the Lehman review, it was suggested (Lehman, page 6) that studies of a number of the beam development questions could be started almost immediately, or after the addition of specific pieces of hardware (e.g. new kicker or RF cavity). Most of this work is best done when the beam physicists are present (i.e. basically one shift per day, not three). Doing the beam tests primarily between RHIC fills would …minimize power bills and people costs. For experiments that pose a risk to machine operation, (those should be scheduled for) the periods immediately after RHIC runs, but then they are only looking at most at a few weeks per year of separate running. The engineers and technicians to actually modify the existing hardware or install new hardware are already included in the AGS upgrade W.B.S. What are needed in addition are beam physicists and possibly controls people, hopefully appreciably less than 12 FTEs.